Space Weather Technical Forecast

Issued on Monday, 06 December 2021 at 00:34 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of G1/Minor Storms day 4 from CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with several C-class flares, and one long duration M1 flare peaking at 05/0718 UTC. This activity was all from over the southwest limb, perhaps AR2898 or another spot that developed near to it as it rotated off the Earth-side. There are two sunspot containing active regions on the Earth-side, AR2902 Axx/Alpha in the northwest which is dissipating as it approaches the limb, and AR2904 Bxo/Beta which has shown some slight growth in the last 6-12 hours, but remains small and simple. Activity from these regions has been Very Low. The CMEs produced by the flare activity are not Earth-directed, however filament eruption in the southern hemisphere at around 05/1200-1330 led to a weak CME being observed which has been assessed has having a potential Earth-directed component, likely arriving 09/1800 +/- 9 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was at slightly elevated levels 420-470km/s, but rose to 530 km/s at 05/2324UTC, likely due to the fast wind of CH27/28. The density of the wind was around or just above average generally 8-12 ppcc. The total interplanetary magnetic field strength (IMF) Bt, was weak, below 7nT, with a north-south component that was generally weakly negative (southward), peaking -6nT but with some brief positive rotations peaking +5nT. The phi angle was predominantly positive (away from the Sun). Resultant geomagnetic activity was generally Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at background levels. The high energy electron flux (greater than 2 MeV) was at moderate to high levels, with a peak through the diurnal cycle of 1240 pfu at 04/1505 UTC and 04/1740 UTC. The associated 24-hour integrated fluence was below the Active threshold (1e8 integrated pfu), with 4.97e7 integrated pfu detected at 06/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Very Low with the chance of further notable flares from around the limb rapidly diminishing, and only two small and simple sunspots on the Earth-facing disc.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CMEs. The first is from a filament eruption on 3rd Dec and whilst expected to miss, may graze Earth on day 3 (7th) although minimal impacts expected if it does. The second is a weak CME from a filament eruption on the 5th, and is expected to arrive day 4 at 09/1800 UTC +/ 9 hours, but again confidence is low due to limited imagery for analysis. Current fast wind from CH27/28 is expected to ease day 2 onward, before a further fast wind enhancement is also possible towards the end of day 4 from CH29. Geomagnetic Activity is forecast to be Quiet to Unsettled with a chance of isolated Active intervals day 1, easing to mainly Quiet day 2 (6th), but with a slight chance of Active from weak CME arrival. Activity increasing day 4 (9th) to Unsettled to Active with the potential combined influence of CH29 and CME arrival giving a slight chance of

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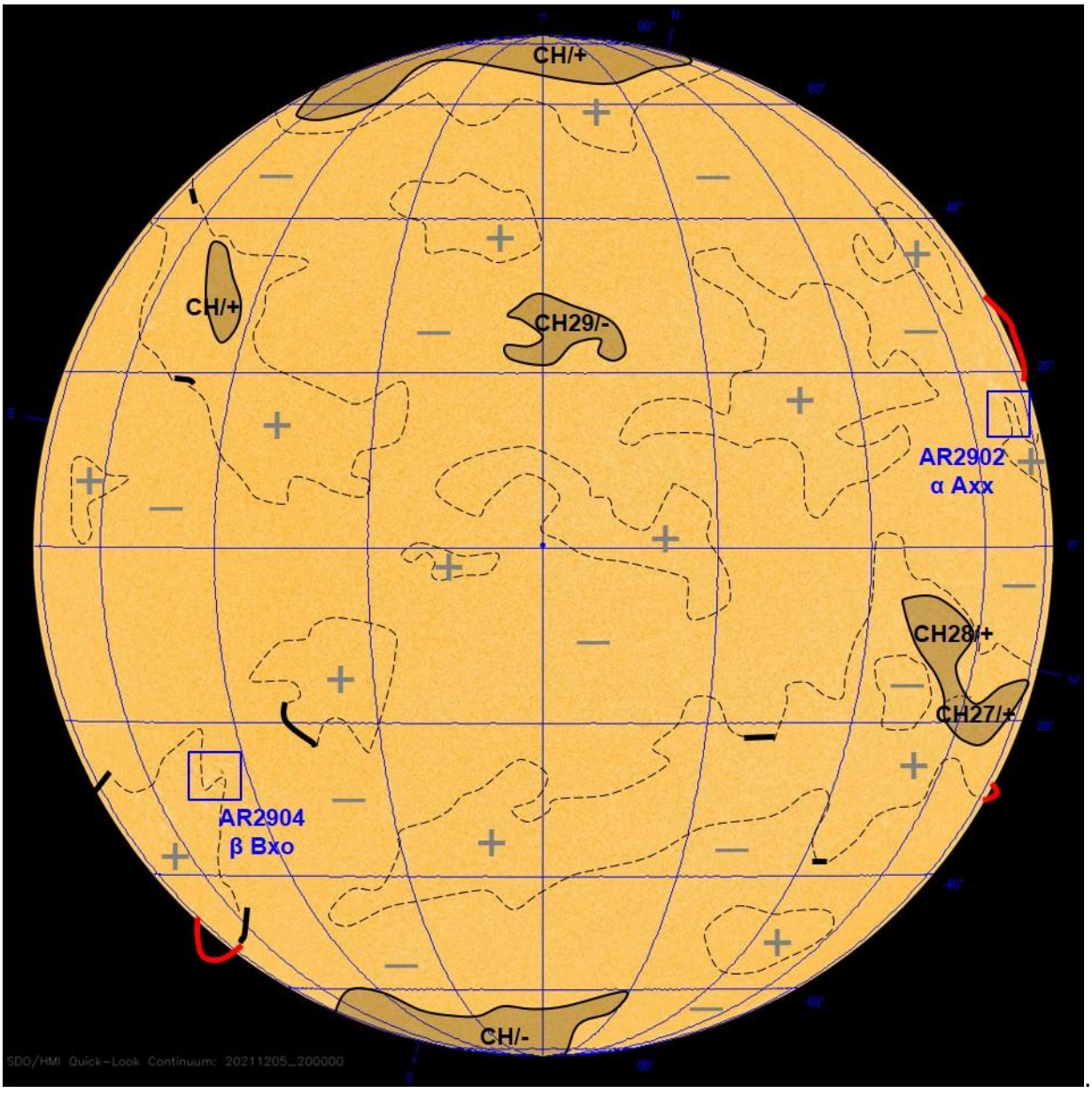
G1/Minor Storm intervals.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels. The high energy electron flux (greater than 2 MeV) is likely to be a moderate to high levels. The associated 24 hour integrated fluence is expected to persist below the Active threshold, but with a rising trend, giving a slight chance of rising above, mainly day 1 or day 2 (6th or 7th).

Figure 1. Solar Analysis Valid 05/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are currently two potentially Earth-directed CMEs. Whilst currently expected to miss, a weak CME from a filament eruption on the 3rd may graze Earth on day 2 (7th), however minimal impacts are expected if it does. A filament eruption from the southern hemisphere on the 5th has also been assessed as being Earth-directed, arriving 09/1800 +/-9 hours, although confidence is low due to its weak signal in SOHO coronagraph imagery, and the lack of current STEREO A imagery.

Slightly elevated to elevated solar winds are likely day 1 (6th) due to ongoing fast wind influence from CH27/+ and CH28/+. These elevated winds easing towards background day 2 (7th) onward. A further weak coronal hole, CH29/-, fast wind has the potential to arrive by the end of day 4, with solar winds becoming slightly elevated.

Geomagnetic Activity is forecast to be Quiet to Unsettled with a chance of isolated Active intervals day 1, easing to mainly Quiet day 2 (6th), but with a slight chance of Unsettled or Active from the weak CME arrival. Activity increasing by the end of day 4 (9th) to Unsettled to Active with the potential combined influence of CH29 and the filament eruption CME giving a slight chance of G1/Minor Storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	1	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Earth-directed CMEs.

Name	Liftoff Time	Long	Lat	Radial Speed (km/s)	Half Angle	Time at 21.5Rs
CME-202112-002	03/12/2021 08:00	26W	14N	282	13	03/12/2021 23:47
CME-202112-007	05/12/2021 13:00	19E	20S	325	30	05/12/2021 23:37

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Figure 2: Solar Wind Persistence Model, showing expected decline of winds after any initial enhancement.

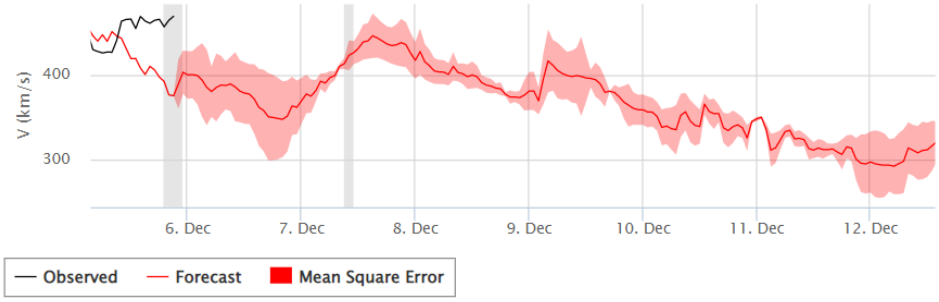


Figure 3: Filament Eruption from south visible in SDO:304

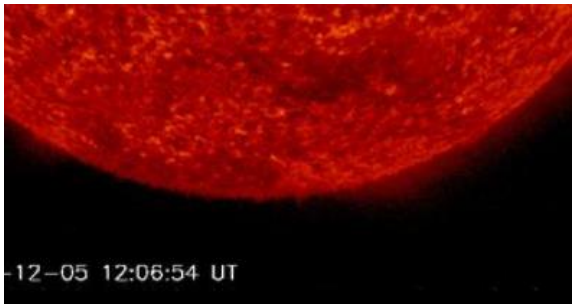
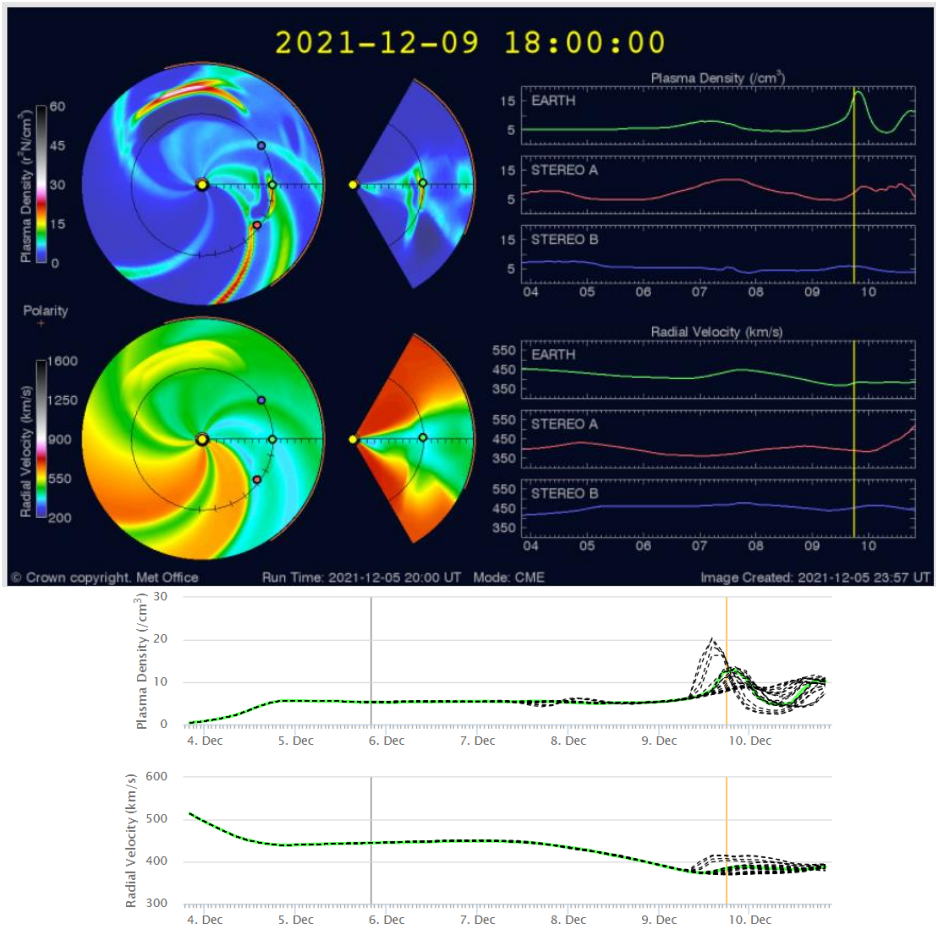


Figure 4: Enlil showing CME arrival with Ensemble showing slight chance of glance also on 7th



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Radio Blackouts - X-Ray Flares:

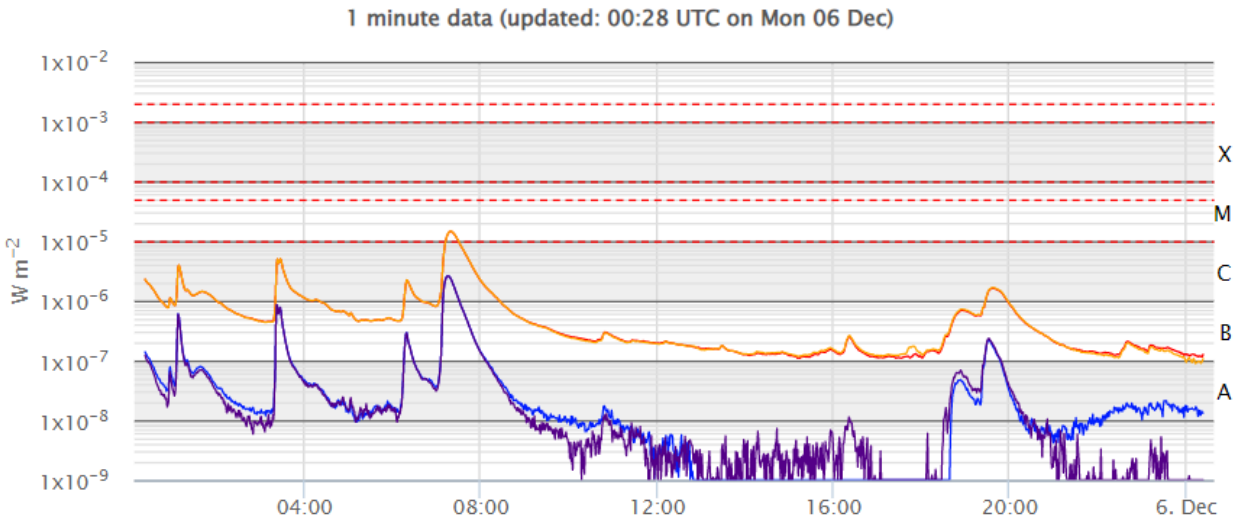
Solar Activity has been Moderate during the last 24 hours, with an M1-flare (R1 Radio Blackout) observed, and a number of C-flares. This activity was due to a region that had already rotated off the Earth-side of the Sun, likely ex-2898 or potentially a further small region that developed to the southeast of this spot. With the chance of further observable flares from this region quickly diminishing as it rotates away, the focus of activity returns to the Earth-side sunspot containing regions. There are currently two such regions, however they are both small and relatively simple.

AR2902 Axx/alpha near the northwest is very small, and difficult to view, as it approaches the limb. AR2904 is a small Bxo/Beta region in the southeast but has shown some sign of development in the last 6 hours with additional spots forming. AR2903 in the southwest has now dissipated.

Activity is forecast to become Very Low, with only a slight chance (10%) of increasing to Low due to any C-class flares, primarily due AR2904.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	1	1	1	1
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 5: GOES 16/17 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels, with no solar radiation storms anticipated.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2 MeV) as observed by GOES-16 has been varying between Moderate and High levels during the last 24 hours, and is forecast to persist at this level, with a low chance of seeing peak values increase day-to-day. There is also the potential for a dropout in values from any geomagnetic activity due to either the initial fast wind enhancement from CH27/28 or the subsequent low chance of a glancing CME on day 2 (7th). A further dropout in values is then likely towards the end of day 4 with the potential arrival of a further CME, alongside the chance of increased geomagnetic activity from the arrival of the fast wind of CH29.

The associated fluence is likely to rise a little day 1, but is likely to stay below the Active with only a slight chance of rising above. There is some uncertainty with the potential for a day-to-day increase of peak flux levels leading to fluence potentially approaching the Active threshold, however REFM is currently suggesting levels remain below it, in-line with this forecast.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	30	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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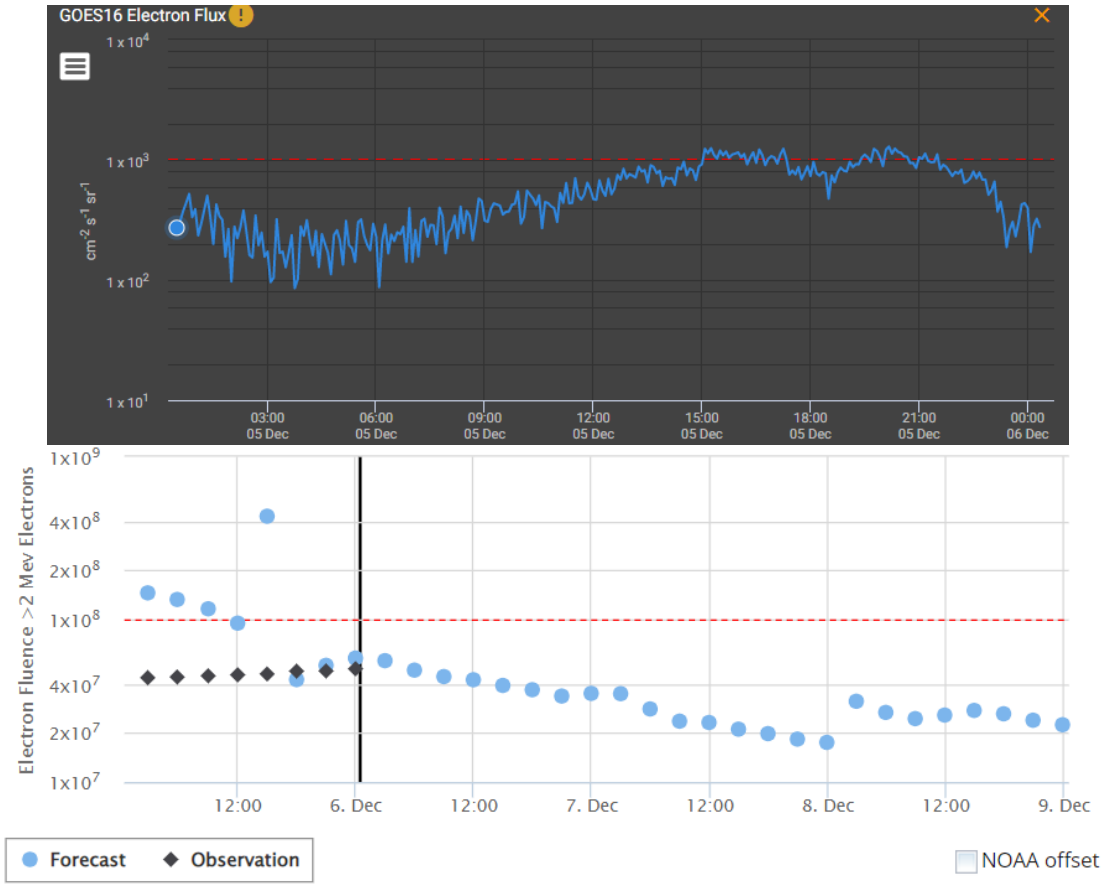
Figure 6: GOES-16 >2MeV Electron Flux and Fluence with REFM



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